

## DOCTORAL SCHOOL OF PHYSICS

**Discipline:** Science

**Form of education:** Doctor of Philosophy (PhD) training

**Objectives:** acquire the academic degree training and the skills necessary in research, development, innovation, and higher-level education

**Length of training:** 8 semesters

**Training type:** regular school

**Financing:** state-sponsored or tuition-fee based

**Entrance requirements:** MSc and a successful entrance exam

**Language requirements:** a type „C” secondary (or equivalent) language exam (preferable in English) recognized by the state (entrance requirement) and a basic level second language exam (exit requirement)

**Training phases:** First two years (period I): 120 ECTS credits, finished with a complex exam

Last two years (period II): 120 ECTS credits, finished with an absolutorium

**Number of ECTS credits required:** 240

**Moduls of ECTS credits:**

**Programs I-III and V:** study credits (48), research credits in the first two years (72), in the last two years (120)

**Program IV (Physics education):** study credits (80), research credits in the first two years (52), in the last two years (120)

**Person responsible for the training:** Dr. Jenő Gubicza, professor of physics, head of the PhD school

### TRAINING MODULE

#### **Program I: Materials Science and Solid State Physics**

Head of the program: Dr. István Groma

**FIZ/1/001** Nanophase metals

6 credit, theory, optional, no repetition

**FIZ/1/004** The finite element method and applications in material science

6 credit, theory, optional, no repetition

**FIZ/1/005** Liquid crystals, polymers

6 credit, theory, optional, no repetition

**FIZ/1/006** Pattern formation in complex systems

6 credit, theory, optional, no repetition

**FIZ/1/009** Micro- and nanotechnology I.

6 credit, theory, optional, no repetition

**FIZ/1/014** Analytical electron microscopy

6 credit, theory, optional, no repetition

**FIZ/1/015** Physical materials science I.

6 credit, theory, optional, no repetition

- FIZ/1/016** Physical materials science II.  
6 credit, theory, optional, no repetition
- FIZ/1/018** Nuclear solid state physics I.  
6 credit, theory, optional, no repetition
- FIZ/1/019** Nuclear solid state physics II.  
6 credit, theory, optional, no repetition
- FIZ/1/021** Transmission electron microscopy and electron diffraction  
6 credit, theory, optional, no repetition
- FIZ/1/022** Advanced Material Physics  
6 credit, theory, optional, no repetition
- FIZ/1/023** Solid state theory  
6 credit, theory, optional, no repetition
- FIZ/1/024** Lattice defects I.  
6 credit, theory, optional, no repetition
- FIZ/1/025** Lattice defects II.  
6 credit, theory, optional, no repetition
- FIZ/1/029** Solid state research I.  
6 credit, theory, optional, no repetition
- FIZ/1/030** Solid state research II.  
6 credit, theory, optional, no repetition
- FIZ/1/031** Technology of materials (intensive course)  
6 credit, theory, optional, no repetition
- FIZ/1/032** Nanomagnetism  
6 credit, theory, optional, no repetition
- FIZ/1/036** Composite materials  
6 credit, theory, optional, no repetition
- FIZ/1/037** Amorphous alloys  
6 credit, theory, optional, no repetition
- FIZ/1/038** Diffraction methods in Materials Science I.  
6 credit, theory, optional, no repetition
- FIZ/1/039** Diffraction methods in Materials Science II.  
6 credit, theory, optional, no repetition
- FIZ/1/040** Bulk nanostructured materials  
6 credit, theory, optional, no repetition
- FIZ/1/041** Quantum bits in solids  
6 credit, theory, optional, no repetition
- FIZ/1/042** Topological insulators I.  
6 credit, theory, optional, no repetition
- FIZ/1/043** Topological insulators II.  
6 credit, theory, optional, no repetition
- FIZ/1/044** Micro and nanotechnology II.  
6 credit, theory, optional, no repetition
- FIZ/1/045** Low temperature plasma physics  
6 credit, theory, optional, no repetition
- FIZ/1/082** Dynamical phenomena in soft materials  
6 credits, theory, optional, no repetition

**FIZ/1,3/013** Quantum chaos in mesoscopic systems  
6 credits, theory, optional, no repetition

**FIZ/1,3/015** Carbon Nanostructures  
6 credits, theory, optional, no repetition

**FIZ/1,3/016** Macromolecules  
6 credits, theory, optional, no repetition

**FIZ/1,3/020** Experimental methods in solid state physics I.  
6 credit, theory, optional, no repetition

**FIZ/1,3/022** Mesoscopic superconductors  
6 credits, theory, optional, no repetition

**FIZ/1,3/023** Physics of mesoscopic systems II.  
6 credits, theory, optional, no repetition

**FIZ/1,3/025** Trapped atomic systems  
6 credits, theory, optional, no repetition

**FIZ/1,3/028** Computer simulations in statistical physics  
6 credits, theory, optional, no repetition

**FIZ/1,3/032** Phase transitions  
6 credits, theory, optional, no repetition

**FIZ/1,3/035** Many-body problem I.  
6 credits, theory, optional, no repetition

**FIZ/1,3/040** Mesoscopic Systems I.  
6 credits, theory, optional, no repetition

**FIZ/1,3/041** Trapped atomic systems II.  
6 credits, theory, optional, no repetition

**FIZ/1,3/042** Cooling and trapping of neutral atoms  
6 credits, theory, optional, no repetition

**FIZ/1,3/052** Experimental methods in solid state physics II.  
6 credit, theory, optional, no repetition

**FIZ/1,3/054** Universality classes in non-equilibrium systems  
6 credits, theory, optional, no repetition

**FIZ/1,3/060** Quantum information theory  
6 credits, theory, optional, no repetition

**FIZ/1,3/062** Superconductivity  
6 credits, theory, optional, no repetition

**FIZ/1,3/065** Synchrotron radiation and applications  
6 credits, theory, optional, no repetition

**FIZ/1,3/066** Theories of open quantum systems  
6 credits, theory, optional, no repetition

**FIZ/1,3/068** Green's functions in nanophysics  
6 credits, theory, optional, no repetition

**FIZ/1,3/073** Group theory in solid state research  
6 credits, theory, optional, no repetition

**FIZ/1,3/074** Introduction to superconductivity  
6 credits, theory, optional, no repetition

**FIZ/1,3/076** Entanglement in quantum many-body systems  
6 credits, theory, optional, no repetition

**FIZ/1,3/079** Stochastic processes  
6 credits, theory, optional, no repetition

**FIZ/1,3/083** Advanced neutron techniques of material characterization  
6 credits, theory, optional, no repetition

## Research module

- FIZ/K18** Guided research work (1,2,3,4. semester)  
18 credit, research, optional, repeatable
- FIZ/K5** Guided research work (5,6,7,8. semester)  
5 credit, research, optional, repeatable
- FIZ/K10** Guided research work (5,6,7,8. semester)  
10 credit, research, optional, repeatable
- FIZ/K15** Guided research work (5,6,7,8. semester)  
15 credit, research, optional, repeatable

## Teaching module (max. credits: 4/semester)

- FIZ/OKT/2** Teaching activity  
2 credits, practice, optional, can be repeated
- FIZ/OKT/4** Teaching activity  
4 credits, practice, optional, can be repeated

## Program II: Particle and Nuclear Physics

Head of the program: Dr. Zoltán Trócsányi

- FIZ/2/001** Advanced field theory  
6 credit, theory, optional, no repetition
- FIZ/2/002** Standard model  
6 credit, theory, optional, no repetition
- FIZ/2/003** Beyond the standard model  
6 credit, theory, optional, no repetition
- FIZ/2/004** Experimental methods of particle physics II  
6 credit, theory, optional, no repetition
- FIZ/2/005** String Theory I  
6 credit, theory, optional, no repetition
- FIZ/2/007** Lattice field theory I.  
6 credit, theory, optional, no repetition
- FIZ/2/008** Solitons and instantons I.  
6 credit, theory, optional, no repetition
- FIZ/2/009** Solitons and instantons II.  
6 credit, theory, optional, no repetition
- FIZ/2/015** Inflationary cosmology  
6 credit, theory, optional, no repetition
- FIZ/2/016** Finite temperature quantum field theory and astrophysical applications  
6 credit, theory, optional, no repetition
- FIZ/2/017** Discrete gauge symmetries  
6 credit, theory, optional, no repetition
- FIZ/2/018** Conform field theories  
6 credit, theory, optional, no repetition
- FIZ/2/019** Field theories with boundaries  
6 credit, theory, optional, no repetition
- FIZ/2/020** Algebraic field theory I.

6 credit, theory, optional, no repetition  
**FIZ/2/021** Introduction to general relativity I.  
6 credit, theory, optional, no repetition  
**FIZ/2/022** Experimental methods of nuclear physics  
6 credit, theory, optional, no repetition  
**FIZ/2/023** Jet physics in hadron hadron and in heavy ion collisions  
6 credit, theory, optional, no repetition  
**FIZ/2/024** The phase diagram of strongly interacting matter  
6 credit, theory, optional, no repetition  
**FIZ/2/043** Introduction to supersymmetry  
6 credit, theory, optional, no repetition  
**FIZ/2/049** Experimental high energy physics: data analysis  
6 credit, theory, optional, no repetition  
**FIZ/2/050** Perturbative conformal field theory  
6 credit, theory, optional, no repetition  
**FIZ/2/052** Algebraic field theory II.  
6 credit, theory, optional, no repetition  
**FIZ/2/053** String theory II.  
6 credit, theory, optional, no repetition  
**FIZ/2/054** String Theory III.  
6 credit, theory, optional, no repetition  
**FIZ/2/055** Lattice field theory II.  
6 credit, theory, optional, no repetition  
**FIZ/2/057** Introduction to general relativity II.  
6 credit, theory, optional, no repetition  
**FIZ/2/077** Introduction to Quantum Integrable Models  
6 credit, theory, optional, no repetition  
**FIZ/2/078** The algebraic Bethe Ansatz and its applications  
6 credit, theory, optional, no repetition  
**FIZ/2/081** Weak interaction  
6 credit, theory, optional, no repetition  
**FIZ/2/083** Quantum chromodynamics  
6 credit, theory, optional, no repetition  
**FIZ/2/084** Integrable field theories  
6 credit, theory, optional, no repetition  
**FIZ/2/086** Solitons and instantons III.  
6 credit, theory, optional, no repetition  
**FIZ/2/094** High energy heavy ion physics and the perfect quark fluid  
6 credit, theory, optional, no repetition  
**FIZ/2/104** Integrable methods in gauge/gravity duality I  
6 credit, theory, optional, no repetition  
**FIZ/2/109** Integrability methods in gauge/gravity duality  
6 credit, theory, optional, no repetition  
**FIZ/2/110** Statistical field theory  
6 credit, theory, optional, no repetition  
**FIZ/2/113** Quantum world  
6 credit, theory, optional, no repetition  
**FIZ/2/117** Selected chapters from experimental high energy physics  
6 credit, theory, optional, no repetition  
**FIZ/2/132** Particle Astrophysics

- 6 credits, theory, optional, no repetition  
**FIZ/2/136** Nuclear physics with radioactive beams  
 6 credit, theory, optional, no repetition  
**FIZ/2/137** Strong interaction at low energies  
 6 credit, theory, optional, no repetition  
**FIZ/2/138** Experimental methods in particle physics  
 6 credit, theory, optional, no repetition

### Research module

- FIZ/K18** Guided research work (1,2,3,4. semester)  
 18 credit, research, optional, repeatable  
**FIZ/K5** Guided research work (5,6,7,8. semester)  
 5 credit, research, optional, repeatable  
**FIZ/K10** Guided research work (5,6,7,8. semester)  
 10 credit, research, optional, repeatable  
**FIZ/K15** Guided research work (5,6,7,8. semester)  
 15 credit, research, optional, repeatable

### Teaching module (max. credits: 4/semester)

- FIZ/OKT/2** Teaching activity  
 2 credits, practice, optional, can be repeated  
**FIZ/OKT/4** Teaching activity  
 4 credits, practice, optional, can be repeated

### Program III: Statistical Physics, Biological Physics and Physics of Quantum Systems

Head of the program: Dr. Jenő Kúrti

- FIZ/3/003** Statistical physics of biological systems  
 6 credit, theory, optional, no repetition  
**FIZ/3/004** Fractal growth  
 6 credit, theory, optional, no repetition  
**FIZ/3/005** Theoretical evolutionary biology  
 6 credit, theory, optional, no repetition  
**FIZ/3/008** Pattern formation in complex systems  
 6 credit, theory, optional, no repetition  
**FIZ/3/009** Liquid crystals and polymers  
 6 credit, theory, optional, no repetition  
**FIZ/3/010** Sensory biophysics  
 6 credit, theory, optional, no repetition  
**FIZ/1,3/013** Quantum chaos in mesoscopic systems  
 6 credit, theory, optional, no repetition  
**FIZ/1,3/015** Carbon Nanostructures  
 6 credit, theory, optional, no repetition

- FIZ/1,3/016** Macromolecules  
6 credit, theory, optional, no repetition
- FIZ/3/017** Physics of environmental flows  
6 credit, theory, optional, no repetition
- FIZ/3/018** Application of chaos theory  
6 credit, theory, optional, no repetition
- FIZ/3/019** Modeling traffic in communication networks  
6 credit, theory, optional, no repetition
- FIZ/1,3/020** Experimental methods in solid state physics I.  
6 credit, theory, optional, no repetition
- FIZ/3/021** Statistical physics of polymers and membranes  
6 credit, theory, optional, no repetition
- FIZ/1,3/022** Mesoscopic superconductors  
6 credit, theory, optional, no repetition
- FIZ/1,3/023** Physics of mesoscopic systems II.  
6 credit, theory, optional, no repetition
- FIZ/1,3/025** Trapped atomic systems  
6 credit, theory, optional, no repetition
- FIZ/3/027** Extreme statistics and their applications  
6 credit, theory, optional, no repetition
- FIZ/1,3/028** Computer simulations in statistical physics  
6 credit, theory, optional, no repetition
- FIZ/3/029** Introduction to quantum optics  
6 credit, theory, optional, no repetition
- FIZ/3/030** Coherent control of quantum systems  
6 credit, theory, optional, no repetition
- FIZ/1,3/032** Phase transitions  
6 credit, theory, optional, no repetition
- FIZ/3/033** Non-equilibrium statistical physics  
6 credit, theory, optional, no repetition
- FIZ/3/034** Mathematical methods in quantum chemistry I.  
6 credit, theory, optional, no repetition
- FIZ/1,3/035** Many-body problem I.  
6 credit, theory, optional, no repetition
- FIZ/3/036** Chaotic Mechanics I.  
6 credit, theory, optional, no repetition
- FIZ/3/037** Environmental fluid hydrodynamics II. EA  
6 credit, theory, optional, no repetition
- FIZ/3/039** Statistical properties of chaos  
6 credit, theory, optional, no repetition
- FIZ/1,3/040** Mesoscopic Systems I.  
6 credit, theory, optional, no repetition
- FIZ/1,3/041** Trapped atomic systems II.  
6 credit, theory, optional, no repetition
- FIZ/1,3/042** Cooling and trapping of neutral atoms  
6 credit, theory, optional, no repetition
- FIZ/3/044** New experiments in quantum mechanics  
6 credits, theory, optional, no repetition
- FIZ/3/045** Sensory biophysics II: Bioacoustics  
6 credit, theory, optional, no repetition

**FIZ/3/048** Dynamical critical phenomenas  
6 credit, theory, optional, no repetition

**FIZ/3/050** Many-body problem II.  
6 credit, theory, optional, no repetition

**FIZ/3/051** Fundamentals of the Physics of Solids II.  
6 credit, theory, optional, no repetition

**FIZ/1,3/052** Experimental metods in solid state physics II.  
6 credit, theory, optional, no repetition

**FIZ/1,3/054** Universality classes in non-equilibrium systems  
6 credit, theory, optional, no repetition

**FIZ/3/055** Systems biology: quantitative analysis of intracellular signal transduction networks  
6 credit, theory, optional, no repetition

**FIZ/3/056** Quantitative models of mechanisms in developmental biology  
6 credit, theory, optional, no repetition

**FIZ/3/059** Evolutionary game theory  
6 credit, theory, optional, no repetition

**FIZ/1,3/060** Quantum information theory  
6 credit, theory, optional, no repetition

**FIZ/1,3/062** Superconductivity  
6 credit, theory, optional, no repetition

**FIZ/3/063** Graphs in bioinformatics  
6 credit, theory, optional, no repetition

**FIZ/3/064** Clustering with networks  
6 credit, theory, optional, no repetition

**FIZ/1,3/065** Synchrotron radiation and applications  
6 credit, theory, optional, no repetition

**FIZ/1,3/066** Theories of open quantum systems  
6 credit, theory, optional, no repetition

**FIZ/1,3/068** Green's functions in nanophysics  
6 credit, theory, optional, no repetition

**FIZ/3/069** Chaotic mechanics II  
6 credit, theory, optional, no repetition

**FIZ/3/070** Quantum electrodynamics in resonator  
6 credit, theory, optional, no repetition

**FIZ/3/071** Molecular and biophysical mechanisms of cell motion  
6 credit, theory, optional, no repetition

**FIZ/1,3/073** Group theory in solid state research  
6 credit, theory, optional, no repetition

**FIZ/1,3/074** Introduction to superconductivity  
6 credit, theory, optional, no repetition

**FIZ/3/075** Extremes, Records, and Order-Statistics in Nature  
6 credit, theory, optional, no repetition

**FIZ/1,3/076** Entanglement in quantum many-body systems  
6 credit, theory, optional, no repetition

**FIZ/3/077** Imaging techniques in modern biology  
6 credit, theory, optional, no repetition

**FIZ/3/078** Fronts and Patterns  
6 credit, theory, optional, no repetition

**FIZ/1,3/079** Stochastic processes



- 6 credit, theory, optional, no repetition  
**FIZ/3/082** Preclinical models in cancer research  
 6 credit, theory, optional, no repetition  
**FIZ/3/083** Python programming and networks  
 6 credit, theory, optional, no repetition  
**FIZ/1,3/083** Advanced neutron techniques of material characterization  
 6 credits, theory, optional, no repetition  
**FIZ/3/084** Data mining and machine learning  
 6 credits, theory and practice, optional, no repetition  
**FIZ/3/085** Data exploration and visualization  
 6 credits, theory and practice, optional, no repetition  
**FIZ/3/086** Data Models and Databases in Science  
 6 credits, theory and practice, optional, no repetition  
**FIZ/3/087** Data science computer lab  
 6 credits, practice, optional, no repetition  
**FIZ/3/088** Advanced statistics and modelling  
 6 credits, theory and practice, optional, no repetition  
**FIZ/3/089** Deep learning and machine learning in natural sciences  
 6 credits, theory optional, no repetition  
**FIZ/3/090** Scientific modelling computer lab  
 6 credits, practice, optional, no repetition  
**FIZ/3/091** Computational Studies of Electron Systems  
 6 credits, practice, optional, no repetition  
**FIZ/3/092** New results in machine learning  
 6 credits, theory and practice, optional, no repetition  
**FIZ/3/093** Advanced machine learning lab  
 6 credits, theory and practice, optional, no repetition

### **Research module**

- FIZ/K18** Guided research work (1,2,3,4. semester)  
 18 credit, research, optional, repeatable  
**FIZ/K5** Guided research work (5,6,7,8. semester)  
 5 credit, research, optional, repeatable  
**FIZ/K10** Guided research work (5,6,7,8. semester)  
 10 credit, research, optional, repeatable  
**FIZ/K15** Guided research work (5,6,7,8. semester)  
 15 credit, research, optional, repeatable

### **Teaching module (max. credits: 4/semester)**

- FIZ/OKT/2** Teaching activity  
 2 credits, practice, optional, can be repeated  
**FIZ/OKT/4** Teaching activity  
 4 credits, practice, optional, can be repeated

## **Program IV: Physics Education**

Head of the program: Dr. Nguyen Quang Chinh

- FIZ/T/001** Physics education I  
5 credit, theory, optional, no repetition
- FIZ/T/002** Foundation of the theory of relativity  
5 credit, theory, optional, no repetition
- FIZ/T/003** Physics of environmental flows  
5 credit, theory, optional, no repetition
- FIZ/T/005** Chaotic mechanics  
5 credit, theory, optional, no repetition
- FIZ/T/006** Versatile use of computers in physics education  
5 credit, theory, optional, no repetition
- FIZ/T/007** Physics of elementary particles  
5 credit, theory, optional, no repetition
- FIZ/T/009** Physics education II (Classical physics, electromagnetism, optics)  
5 credit, theory, optional, no repetition
- FIZ/T/010** Physics education III (Modern physics: atomic physics, molecular and nuclear physics)  
5 credit, theory, optional, no repetition
- FIZ/T/011** Physics education IV (Modern physics: statistical physics, relativity, material science, nonlinear phenomena)  
5 credit, theory, optional, no repetition
- FIZ/T/013** Historically relevant experiments of Physics  
5 credit, theory, optional, no repetition
- FIZ/T/016** Energetics and environment  
5 credit, theory, optional, no repetition
- FIZ/T/020** Cooperative phenomena, interdisciplinary aspects  
5 credit, theory, optional, no repetition
- FIZ/T/021** Physics in biology  
5 credit, theory, optional, no repetition
- FIZ/T/022** Physics in chemistry  
5 credit, theory, optional, no repetition
- FIZ/T/023** Recent results in astronomy and space science  
5 credit, theory, optional, no repetition
- FIZ/T/024** Plausible quantum theory  
5 credit, theory, optional, no repetition

### **Research module**

- FIZ/K4/16** Guided research work (in semesters: 1, 2, 3, 4)  
4, 16, 16, 16, credits/semester, research, optional, repeatable
- FIZ/K5** Guided research work (5,6,7,8. semester)  
5 credits, research, optional, repeatable
- FIZ/K10** Guided research work (5,6,7,8. semester)  
10 credits, research, optional, repeatable
- FIZ/K15** Guided research work (5,6,7,8. semester)  
15 credits, research, optional, repeatable

## **Program V: Astronomy and Space Physics**

Head of the program: Dr. Kristóf Petrovay

- FIZ/5/001 [034]** Observational methods in astrophysics  
6 credits, theory, optional, no repetition
- FIZ/5/002 [129]** Astronomy with ESO instrumentation  
6 credits, theory, optional, no repetition
- FIZ/5/003 [026]** Astrostatistics I.  
6 credits, theory, optional, no repetition
- FIZ/5/004 [059]** Astrostatistics II.  
6 credits, theory, optional, no repetition
- FIZ/5/005 [075]** Working with astronomical databases  
6 kredit, gyakorlat, választható, nem ismételhető
- FIZ/5/006 [119]** Data mining in astronomy  
6 credits, theory, optional, no repetition
- FIZ/5/007 [031]** Advanced infomation technology in astronomy I.  
6 credits, theory, optional, no repetition
- FIZ/5/008 [064]** Advanced infomation technology in astronomy II.  
6 credits, theory, optional, no repetition
- FIZ/5/009 [032]** Radio astronomy I.  
6 credits, theory, optional, no repetition
- FIZ/5/010 [065]** Radio astronomy II.  
6 credits, theory, optional, no repetition
- FIZ/5/011 [038]** Astrophysical turbulence, dynamos and reconnection 1. LCT  
6 credits, theory, optional, no repetition
- FIZ/5/012 [067]** Astrophysical turbulence, dynamos and reconnection II. LCT  
6 credits, theory, optional, no repetition
- FIZ/5/013 [039]** Astronomy from space I.  
6 credits, theory, optional, no repetition
- FIZ/5/014 [072]** Astronomy from space II.  
6 kredit, egyéni kutatás, választható, nem ismételhető
- FIZ/5/015 [040]** Infrared Astronomy I  
6 credits, theory, optional, no repetition
- FIZ/5/016 [068]** Infrared Astronomy II. GY  
6 kredit, gyakorlat, választható, nem ismételhető
- FIZ/5/017 [076]** Chapters from moder astronomy and cosmology  
6 kredit, előadás, választható, nem ismételhető
- FIZ/5/018 [107]** N-body simulations in astrophysics and cosmology  
6 credits, theory, optional, no repetition
- FIZ/5/019 [126]** Cosmology  
6 credits, theory, optional, no repetition
- FIZ/5/020 [074]** The distant universe  
6 kredit, előadás, választható, nem ismételhető
- FIZ/5/021 [127]** Gravitational wave astrophysics  
6 credits, theory, optional, no repetition
- FIZ/5/022 [118]** High energy astrophysics  
6 credits, theory, optional, no repetition
- FIZ/5/023 [122]** The physics of black holes  
6 credits, theory, optional, no repetition
- FIZ/5/024 [123]** Selected chapters from the study of the structure of compact stars

- 6 credits, theory, optional, no repetition  
**FIZ/5/025 [080]** The structure of compact stars  
6 kredit, előadás, választható, nem ismételtető
- FIZ/5/026 [121]** Active galactic nuclei  
6 credits, theory, optional, no repetition
- FIZ/5/027 [027]** Dynamics of stellar systems I.  
6 credits, theory, optional, no repetition
- FIZ/5/028 [060]** Dynamics of stellar systems II.  
6 credits, theory, optional, no repetition
- FIZ/5/029 [120]** Stellar and galaxy populations  
6 credits, theory, optional, no repetition
- FIZ/5/030 [037]** Current research results in interstellar matter and star formation I.  
6 credits, theory, optional, no repetition
- FIZ/5/031 [025]** The physics of interstellar matter I.  
6 credits, theory, optional, no repetition
- FIZ/5/032 [058]** The physics of interstellar matter II.  
6 credits, theory, optional, no repetition
- FIZ/5/033 [070]** Accretion processes in star formation  
6 kredit, gyakorlat, választható, nem ismételtető
- FIZ/5/034 [093]** Light variations in young stellar objects  
6 credits, theory, optional, no repetition
- FIZ/5/035 [033]** Stellar activity – active stars I.  
6 credits, theory, optional, no repetition
- FIZ/5/036 [066]** Stellar activity – active stars II.  
6 credits, theory, optional, no repetition
- FIZ/5/037 [115]** Pulsating variables and their observation I.  
6 credits, theory, optional, no repetition
- FIZ/5/038 [116]** Pulsating variables and their observation II.  
6 credits, theory, optional, no repetition
- FIZ/5/039 [114]** Pulsation theory  
6 credits, theory, optional, no repetition
- FIZ/5/040 [101]** Exoplanetary research  
6 credits, theory, optional, no repetition
- FIZ/5/041 [099]** Chapter sfrom the theory and observations of multiple stellar and planetary systems I.  
6 credits, theory, optional, no repetition
- FIZ/5/042 [100]** Chapter sfrom the theory and observations of multiple stellar and planetary systems II.  
6 credits, theory, optional, no repetition
- FIZ/5/043 [130]** (Exo)planetary atmospheres seminar I.  
6 credits, theory, optional, no repetition
- FIZ/5/044 [131]** (Exo)planetary atmospheres seminar II.  
6 credits, theory, optional, no repetition
- FIZ/5/045 [103]** The formation of planets and planetary systems  
6 credits, theory, optional, no repetition
- FIZ/5/046 [098]** Small and microscopic Solar System bodies  
6 credits, theory, optional, no repetition
- FIZ/5/047 [133]** At the edge of the Solar System 1  
6 credits, theory, optional, no repetition
- FIZ/5/048 [134]** At the edge of the Solar System 2

- 6 credits, theory, optional, no repetition
- FIZ/5/049 [102]** Dwarf planets in the Solar System  
6 credits, theory, optional, no repetition
- FIZ/5/050 [105]** Chaos detection methods in Hamiltonian systems. - Applications in celestial mechanics  
6 kredit, gyakorlat, választható, nem ismételhető
- FIZ/5/051 [029]** Perturbation methods in celestial mechanics I.  
6 credits, theory, optional, no repetition
- FIZ/5/052 [062]** Perturbation methods in celestial mechanics II.  
6 credits, theory, optional, no repetition
- FIZ/5/053 [125]** Chapters from modern celestial mechanics  
6 credits, theory, optional, no repetition
- FIZ/5/054 [073]** Lineár and nonlinear MHD waves  
6 kredit, előadás, választható, nem ismételhető
- FIZ/5/055 [082]** Solar System plasma physics  
6 kredit, előadás, választható, nem ismételhető
- FIZ/5/056 [095]** Physics of the heliosphere  
6 credits, theory, optional, no repetition
- FIZ/5/057 [128]** Solar physics  
6 credits, theory, optional, no repetition
- FIZ/5/058 [071]** Physics of the solar atmosphere  
6 kredit, gyakorlat, választható, nem ismételhető
- FIZ/5/059 [135]** Space weather and space climate  
6 credits, theory, optional, no repetition

### Research module

- FIZ/K18** Guided research work (1,2,3,4. semester)  
18 credit, research, optional, repeatable
- FIZ/K5** Guided research work (5,6,7,8. semester)  
5 credit, research, optional, repeatable
- FIZ/K10** Guided research work (5,6,7,8. semester)  
10 credit, research, optional, repeatable
- FIZ/K15** Guided research work (5,6,7,8. semester)  
15 credit, research, optional, repeatable

### Teaching module (max. credits: 4/semester)

- FIZ/OKT/2** Teaching activity  
2 credits, practice, optional, can be repeated
- FIZ/OKT/4** Teaching activity  
4 credits, practice, optional, can be repeated

## List of complex examination topics

In Programs I-III and V one can choose the *main topics* from the following list:

Astrophysics, Space Physics, Biophysics, Material science, Quantum mechanics, Atomic and molecular physics, Nuclear physics, Optics, Particle Physics, Statistical physics, Solid state physics, Network theory,

In Program IV the main topics is Physics education.

*Secondary topics* in Programs I-III and V (all optional):

Solar Physics, Physics of the Solar System, Celestial mechanics, Galactic astronomy, Stellar astrophysics, Physics of the interstellar medium, Extragalactic astronomy, Cosmology, High energy astrophysics, Physics of exoplanets and exoplanetary systems, Signal processing. Data-intensive and machine learning methods. Molecular biophysics, Bioinformatics, Methods of physics in biology, Evolution theory, Environmental physics, Mathematical foundations of relativistic quantum theory, Renormalization and the renormalization group, Optical and particle spectroscopy, Plasma physics, Heavy ion physics, Reactor physics and radiation protection, Applications of nuclear methods, Theory of gravitation; Quantum information, Experimental quantum mechanics, Quantum optics and lasers, Quantum electrodynamics, Low energy hadron physics and nonperturbative quantum chromodynamics, Quantum chromodynamics, Phenomena and theory of electroweak interaction, Experimental methods and data processing in particle physics, Chaotic systems, Growth phenomena and pattern formation, Phase transitions and critical phenomena, Computational methods in statistical physics, Hydrodynamics, Defects in metals and insulators, Mechanical properties of solids, Experimental methods in solid state research and material science, Liquid crystals, Magnetic properties of condensed matter, Optical properties of condensed matter, Many-body problem, Mesoscopic electron systems, Carbon nanostructures, **Topological insulators**, Computational methods in material science and solid state physics, Physics of amorph materials and nanostructures, Physics of membranes and macromolecules; Nuclear astrophysics; Standard model of particle interactions; Beyond the standard model; Particle astrophysics

*Secondary topics* in Program IV can be chosen by merging two topics of the following list:

Historically relevant experiments of Physics, Foundation of the theory of relativity Plausible quantum theory, Physics of elementary particles, Energetics and environment, Physics of environmental flows, Chaotic mechanics, Versatile use of computers in physics education, Cooperative phenomena, interdisciplinary aspects, Physics in biology, Physics in chemistry, Recent results in astronomy and space science

## **Evaluation and control**

Fulfilment of the requirements of a given course is evaluated and recorded in the transcript by the lecturer on a five-point scale (1-2-3-4-5, 1: failed .. 5: excellent). Research activities are evaluated and recorded in the transcript by the supervisor on a three-point scale (excellent – acceptable – failed). Credits are approved by the program directors. Outstanding research achievements, proved by scientific publications, books or books chapters, can be honored by a maximum of 60 ECTS credits. A request for such credits should be submitted by the student and approved by the Council of the PhD School.